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SHORT COMMUNICATION

Pseudoscorpions (Chelonethi: Neobisiidae) parasitized by mites (Acari: Trombidiidae, Erythraeidae)

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Abstract. Records of mites parasitizing pseudoscorpions are summarized and new host-parasite associations are reported. *Trombidium brevimanum* (Berlese 1910) (Trombidiidae) has been found on *Neobisium bernardi bernardi* Vachon 1937 in France (new country record for *T. brevimanum*), and *T. mediterraneum* on *N. carcinoides* (Hermann 1804) in Norway (new country record for *T. mediterraneum*). These are the first cases in which both the mite and the pseudoscorpion have been identified. An additional record of *Trombidium* sp. (probably *T. mediterraneum*) on *Neobisium fuscimanum* (C.L. Koch 1843) is given from Poland. A previously unpublished record of a *Leptus* larva on a pseudoscorpion, possibly belonging to the genus *Neobisium*, is noted from France. Parasitism of *Roncus lubricus* L. Koch 1873 by an unidentified larva of Parasitengona (probably Trombidiidae) is also noted from Germany. The stylostomes (feeding canals) formed in pseudoscorpions by trombidiid mites are similar to those produced in other hosts. Scars in the pleurum of the pseudoscorpions are interpreted as the result of attempts at fixation by the mite larvae. Pseudoscorpions appear to represent alternative hosts for *Trombidium* larvae, although the successful completion of development has yet to be demonstrated.

Keywords: Parasitengona, Pseudoscorpiones, host-parasite associations, stylostome

Mites of the group Parasitengona (variously treated as a cohort or suborder of Actinotrichida) are mostly protelean parasites, in which the larva is parasitic, whereas the active postlarval stages (deutonymph and adult) are predatory or, rarely, pollinivorous. Except for Trombiculidae, which parasitize vertebrates, the great majority of Parasitengona use arthropods as hosts (Wohltmann 2001). In Trombiculidae (chiggers), Trombidiidae (velvet mites) and Hydrachnidia (water mites), feeding occurs via a stylostome—a simple or branching tube formed within the host tissues by the mite larva (Wharton 1954; Wohltmann 2001).

Records of parasitism on pseudoscorpions are infrequent in the literature and in no case have both the host and the parasite been identified to species. Womersley (1934) described *Leptus chelonethus* Womersley 1934 (Erythraeidae) from a single larva parasitizing an unidentified pseudoscorpion in Australia. Robaux (1974) recorded *Trombidium meyeri* (Krausse 1916) (now a synonym of *T. rimosum* C.L. Koch 1837: see Mąkol 2005) parasitic on a protonymph of an unidentified species of *Neobisium* Chamberlin 1930 (locality not specified, presumably in France), but the identification of the mite is now considered doubtful (Mąkol 2005). Weygoldt (1969) found several individuals of *Neobisium muscorum* (Leach 1817) [now a synonym of *N. carcinoides* (Hermann 1804): see Mahnert 1988] parasitized by trombidiform mite larvae in Germany. Austin et al. (1998) refer to a record of '*Trombidium* sp.' on an 'unidentified pseudoscorpion' in Welbourn (1983), but the latter simply lists Robaux's (1974) record. Thus, there have been only three published instances of Parasitengona parasitizing pseudoscorpions. Even if other examples may have gone unrecorded due to lack of interest, it is evident that such host-parasite associations are rare. Here we present new records of mite larvae of the genus *Trombidium* Fabricius 1775 (Trombidiidae) parasitizing adult pseudoscorpions of the genus *Neobisium* Chamberlin 1930 (Neobisiidae) in France, Norway and Poland. We also provide evidence from indirect sources for the first record of mite parasitism on a species of *Roncus* L. Koch 1873 (Neobisiidae) and the first known case of a *Leptus* species (Erythraeidae) parasitizing a pseudoscorpion in Europe.

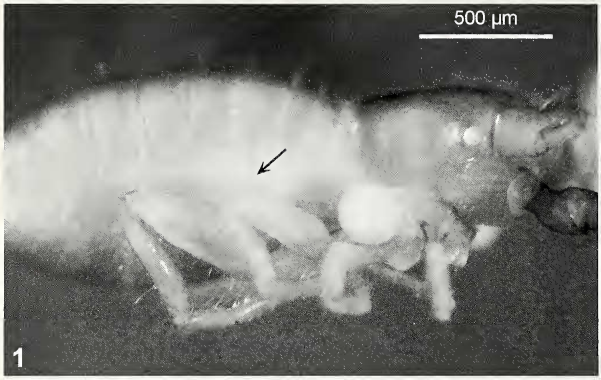
METHODS

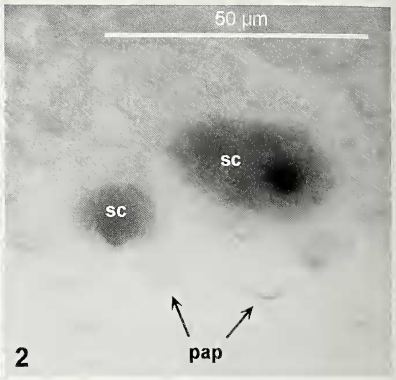
Preserved material studied here is deposited in the collections of the Muséum national d'Histoire naturelle, Paris (MNHN) and the Department of Invertebrate Systematics and Ecology, Wrocław University of Environmental and Life Sciences (DISE). Pseudoscorpions were identified in temporary glycerin mounts. The stylostome and scars of the parasitized *Neobisium bernardi* Vachon 1937 were examined by clearing the specimen (after removal of mites and appendages) for four days in 50% lactic acid at room temperature. Mites were identified from specimens removed from hosts, cleared in Nesbitt's fluid (Nesbitt 1945) and mounted on slides in Swan's fluid (Swan 1936).

RESULTS

***Trombidium brevimanum* on *Neobisium bernardi* (Figs. 1–3).**—An adult male of *Neobisium bernardi bernardi* Vachon 1937, collected from leaf litter at Pause du Saut (42°51′02″N, 0°59′07″E), Ariège, France, 1–2 June 1991 by J.A. Murphy, was found to be parasitized by two larvae of *Trombidium brevimanum* (Berlese 1910) (pseudoscorpion in alcohol, MNHN-Ps250.2331.1; larvae on slides, MNHN Ac1140 and DISE). Thirteen other adults (9 ♂, 4 ♀; Ps250.2331.2–12) of *N. bernardi* were collected at the same time, none of which carried mites.

The mites were attached to the pleural membrane, above coxa II (Fig. 1) on the right side and above opisthosomal sternite VI on the left side. The stylostome (a feeding canal formed within the host tissues) of the engorged mite has the same general form as that produced by *Trombidium* larvae in other hosts (Wharton 1954; Mąkol & Wohltmann 2000; Wohltmann 2001; Mohamed & Hogg 2004), except that the branching is less extensive (perhaps not yet fully formed). It consists of a tube (ca length 75 µm, diam. 10 µm, wall thickness 3.7 µm) that branches apically (Fig. 3). The external opening is flanked by a pair of internal marks that form a crescent-shape (Fig. 3: *cr*), left by the cheliceral digits (cf. Mąkol & Wohltmann 2000). No stylostome was found under the





Figures 1, 2.—*Neobisium bernardi* male parasitized by larvae of *Trombidium brevimanum*. 1. Lateral view showing engorged larva, arrow indicates position of scars; 2. Scars in opisthosomal pleurum of pseudoscorpion, on left side above sternite VI (anterior end of pseudoscorpion to left of photograph), caused by unfed mite larva. Abbreviations: *pap* papillae of pleurum, *sc* scar.

unengorged larva; instead, there were two spots of brown, darkened tissue below the cuticle (Fig. 2). Such darkened tissue is typically associated with wound healing in pseudoscorpions (M. Judson, unpubl. observ.). Another scar was present on the right side of the opisthosoma, in the pleural membrane below tergite IV (Fig. 1, arrow). This could represent an aborted attempt at fixation by the larva before it moved forward to the prosoma. No darkened tissue was associated with the stylostome formed by the engorged larva.

Neobisium bernardi bernardi seems to be restricted to the Pyrénées, being recorded from forest litter in the departments of Ariège, Aude, Hautes Pyrénées and Pyrénées Atlantiques (Heurtault 1986). Two other subspecies have been described: *Neobisium bernardi franzi* Beier 1955 from Spain and Portugal, and *Neobisium bernardi gennargentui* Callaini 1983, from Sicily. *Trombidium brevimanum* is a common and widespread species in Europe (Mąkol 2005), but this is the first time that it has been recorded from France. Its usual hosts are spiders (Wohltmann 1999).

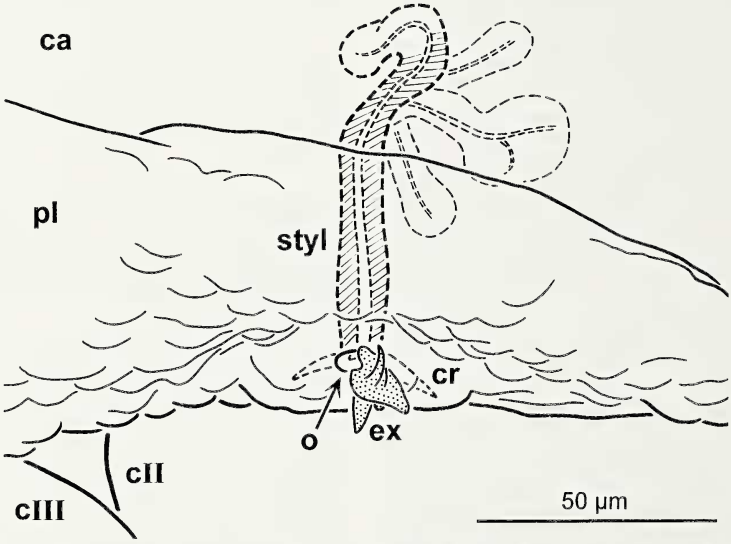


Figure 3.—Stylostome of *Trombidium brevimanum* within prosoma of *Neobisium bernardi*, lateral view (anterior end of pseudoscorpion to right). Abbreviations: *ca* carapace; *cII* coxa of leg II; *cIII* coxa of leg III; *cr* crescent-shaped internal wound; *ex* external part of stylostome; *o* external opening of stylostome; *pl* pleural membrane; *styl* stylostome.

Figures 4, 5.—*Neobisium carcinoides* male parasitized by ten larvae of *Trombidium mediterraneum*. 4. Dorsal view, showing larvae in various states of engorgement (to same scale as Fig. 5); 5. Lateral view (after removal of one larva from anterior end of opisthosoma).

***Trombidium mediterraneum* on *Neobisium carcinoides*.**—An adult male of *Neobisium carcinoides carcinoides* (Hermann 1804), collected from soil/litter in *Alnus incana incana*/*Prunus padus* woodland, Morud (60°3′37″N, 9°51′34″E), Norway, ca 200 m a.s.l., 6 June 2001, by M. Gulvik, was parasitized by ten larvae of *Trombidium mediterraneum* (Berlese 1910) (pseudoscorpion with 4 attached larvae in alcohol, MNHN-Ac1139; 3 detached larvae in alcohol and 3 larvae on slides, DISE). All mites were attached to the pleural membrane (4 on left, 6 on right), from the level of coxa II to opisthosomal segment VII (Figs 4–5). The pseudoscorpion has a significant amount of dirt adhering to its venter, but it is possible that this is the result of storage in an unsorted Tullgren extraction. The stylostomes are much longer and more extensively branched than those seen for *T. brevimanum* on *N. bernardi*, being similar to those illustrated for *Trombidium 'newelli'* (nom. nud.) parasitizing alfalfa weevils (Mohamed & Hogg 2004). A detailed examination was not carried out because this would require dissection of the pseudoscorpion and we have preferred to keep this exceptional specimen intact. As in the previous case, the stylostomes are colorless and there is no darkening of the surrounding tissues.

Neobisium carcinoides is common and widespread in the western Palaearctic (Harvey 2009), usually being found in forest litter. *Trombidium mediterraneum* has a wide distribution in the western Palaearctic, but this is the first time it has been recorded from Norway. Adults of this species have also been found in Norway (J. Łaydanowicz, pers. comm.). The normal hosts are Lepidoptera (Robaux 1974; Mąkol 2005).

***Trombidium* sp. on *Neobisium fuscimanum*.**—An adult female of *Neobisium fuscimanum* (C.L. Koch 1843), from Poland, Lower Silesia, Rez. Muszkowicki Las Bukowy (Muszkowice Beech Forest nature reserve; 50°38′28.31″N, 16°56′56.34″E, elev. 258 m), litter, 23 May 1992, leg. B. Pokryszko, was found carried one engorged larva of *Trombidium* sp. (pseudoscorpion in MNHN, Ps616.0001; mite in DISE). Unfortunately, the mite was damaged and could not be identified to species with certainty, but it probably belongs to *T. mediterraneum*. It was attached to the pleural membrane of the prosoma above the posterior margin of coxae I. The pseudoscorpion is a relatively old adult, as indicated by extensive wear of the cheliceral teeth and the large number of broken teeth on the chelal fingers (19% of all acute teeth). There are also initial signs of internal fungal growth (filaments penetrating body at the right side of carapace, left stigmata II and lateral edge of left sternite V). Nevertheless, the pseudoscorpion has a generally healthy appearance and is replete, which indicates that it was still active and capable of feeding when collected.

Neobisium fuscimanum is found in leaf litter in central Europe, the Balkans, Anatolia and Iran (Harvey 2009).

Unidentified Parasitengona on *Roucus lubricus*.—During the preparation of this paper we received two short videos by Prof. G. Alberti

of a pseudoscorpion parasitized by a terrestrial Parasitengona larva. These were collected from leaf litter in the surroundings of Greifswald, Germany, but unfortunately the specimens are no longer available for study. Nevertheless, the pseudoscorpion can be recognized as a species of *Roncus* and it can be assumed that it is *R. lubricus* L. Koch 1873, since this is the only species of the genus known from Germany (Harvey 2009). The mite is engorged and cannot be identified, but its appearance is at least consistent with that of Trombidiidae. The videos show the parasitized pseudoscorpion moving normally and feeding on a springtail (Collembola). This is the first record of parasitism by a mite on a member of the genus *Roncus*.

***Leptus* sp. on unidentified pseudoscorpion.**—The catalogue of the MNHN mite collection lists a slide-mounted larva identified by Marc André as *Leptus 'phalangii'* (de Geer 1778) (MNHN-Acl76), labeled as being from "*Obisium*?" collected in moss at an unspecified locality in France, July 1934, and donated by J. Millot. Unfortunately, this specimen has been on loan for many years and attempts to obtain its return have so far been unsuccessful. Although we are unable to confirm the identification, we consider this record worth mentioning here because it is the first of *Leptus* parasitizing a pseudoscorpion in Europe and only the second of an erythraeid mite on this type of host. Unless mounted on the same slide, the host has not been deposited in the MNHN and thus cannot be identified, although it is likely to have been a species of *Neobisium*.

DISCUSSION

The rarity of larvae of *Trombidium* and *Leptus* on pseudoscorpions suggests that they are not normal hosts. Weygoldt (1969) attempted to rear larvae of a 'trombidiform mite' (possibly *Trombidium*) found on *Neobisium*, but this failed due to death of the host. Nevertheless, several of the mites we examined are engorged and the pseudoscorpions have a healthy appearance, so it is likely that some *Trombidium* species can develop successfully using *Neobisium* as a host. The low frequency of parasitism by mites on pseudoscorpions in general might reflect the fact that the larvae of Parasitengona lie within the normal size range of prey for a pseudoscorpion and would have difficulty approaching one without being attacked. The production of silk molting nests by pseudoscorpions may also reduce levels of parasitism, because hosts are more vulnerable to attack by parasitic mites immediately after molting (Wohltmann 2001). Whatever the reason, it is clear that parasitic mites do not have a significant impact on pseudoscorpion populations.

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